

Automatic Spray Painting Robot using Regression



Swetha Danthala, Seeram Srinivasa Rao

Abstract: The main of the paper is to take up parametric optimization for an automatic spray painting robot which helps to reduce operational cost and time. The painting chemicals can cause hazards to the painters such as eye and respiratory system problems. When construction workers the robots are properly used in buildings and whole construction process can be better manage to savings the human labor and timing by applying the machine learning techniques we find out the surface roughness thickness variation, film adhesion.

Keywords : Robotics, Construction, spray painting, safety

I. INTRODUCTION

At present spray painting is extensively used in many fields such as automobiles, home appliances etc. One of the oldest applications of industrial robots is spray painting preferred for their quality output cost effectiveness.

Mohammed [1] In his work described spray painting robot which consists of an arm that scans the wall vertically and fitted to the robot base to give lateral feed motion to cover the painting area.

Pkeerthana et al. [2] designed a wall painting robot using conveyor belt, shaft, spray gun and controller unit. Due to the less number of moving parts it gave expected performance.

Fengyu Xu et al. [3] have given wall climbing robot design with claws. Jizhong Xiao et al [4] worked on wall climbing robot with load carrying capacity. Robotic spray painting [5] thickness is measured in [μm] by considering different spray painting parameters like paint flow, viscosity, gravity surface tension easily deposition of paint quality measured values. The quality of the paint is measured in terms of surface roughness, thickness variation, and film adhesion. Various robotic applications are discussed in [6-13] for mechanical engineering requires design parameters for optimizing the robot automation. Various optimizing techniques [14-19] can be used depending on the input parameter behavior.

II. EXPERIMENTAL SETUP & PROCEDURE

R Balamurugan, & S. Prabhu [20] experimented on IRB 1410 robot with a specially designed end effectors with spray gun. The payload capacity of the manipulator is 5kg and reaches 1.45 m and is control by IRC5 controller. For this experiment a gravity feed HVLP Spray gun is used which has an improved atomization capability for maximum transfer efficiency HVLP spray gun with pressure pot and separate paint tank initial as well as the changing of paint type.

TABLE -I CONTROL FACTORS SPECIFICATIONS:
(courtesy: R Balamurugan, & S. Prabhu [20])

Item	Control factor	Units	Level1	Level2	Level3
A	Distance	Mm	100	125	150
B	Pressure	Bar	2	2.25	2.5
C	Speed	mm/s	75	90	105

TABLE -II: L9 ORTHOGONAL ARRAY

Experiment	Distance	Pressure	Speed
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Here 3 factors 3 levels available of DOF is 6. The above array table consists of 3 columns and 9 rows so taguchi L9 allows conducting only 9 experiments to investigate the control variables to cover the area of surface to be painted.

TABLE -III Results & Discussion

(courtesy: R Balamurugan, & S. Prabhu [20])

Expt no	Distance	Pressure	Speed	TV [μm]	SR [μm]	FA [%]
1	1	1	1	9.0	0.1020	96.50
2	1	2	2	2.0	0.1100	95.50
3	1	3	3	9.0	0.1620	98.50
4	2	1	2	5.5	0.1040	97.50
5	2	2	3	5.5	0.0960	97.50
6	2	3	1	18.0	0.1300	98.50
7	3	1	3	18.0	0.0830	98.90

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Automatic spray painting robot: design parameters analysis

8	3	2	1	14.0	0.0700	98.50
9	3	3	2	18.0	0.1370	98.90

The control factors used by [20] are shown in Table I, L9 orthogonal array is shown in Table II and Table III shows results obtained by the experimentation [20]

The variation of thickness, surface roughness and film adhesion with respect to different parameters such as distance, pressure, speed have been shown in the figures. The figure1 shows the thickness variation of the paint with respect to the distance of the spray paint gun from the object to be painted. From the figure1 it is understood that the change in the thickness variation is more, when the paint gun distance has changed from 125mm to 150mm.

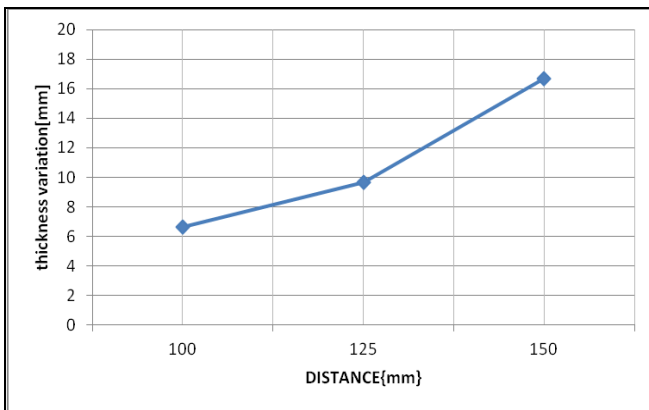


Fig1: DISTANCE vs THICKNESS VARIATION:

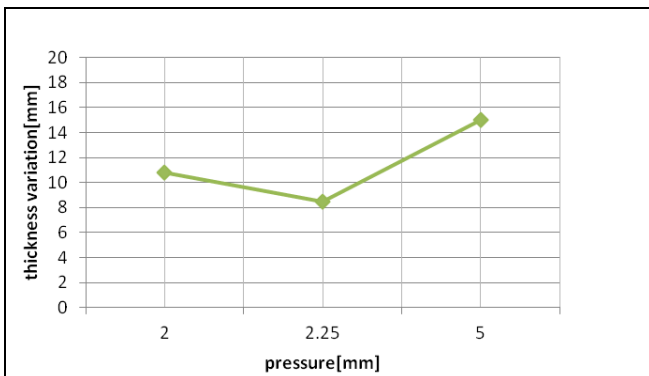


Fig.2: PRESSURE vs THICKNESS VARIATION:

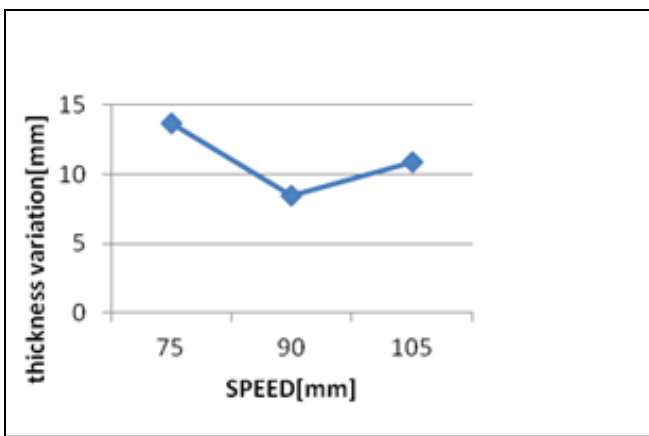


Fig.3:SPEED vs THICKNESS VARIATION:

The figure4 shows the surface roughness of the paint with respect to the distance of the spray paint gun from the object to be painted. From the figure4 it is understood that the surface roughness is decreased as the distance increases.

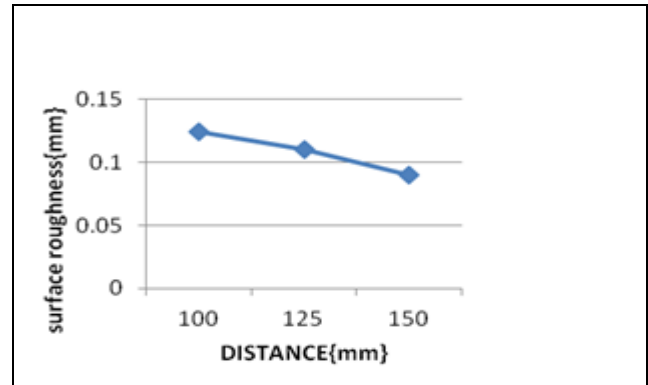


Fig4: DISTANCE vs SURFACE ROUGHNESS

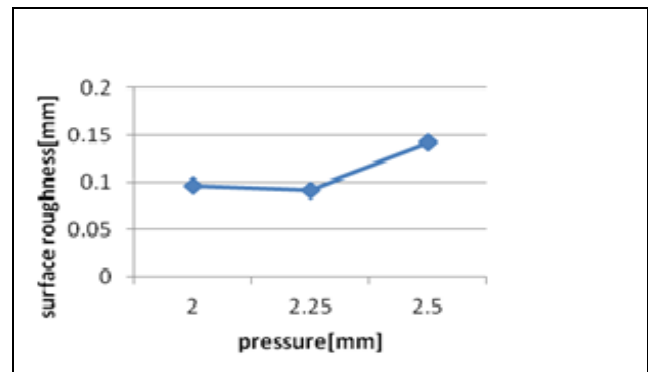


Fig 5:PRESSURE vs SURFACE ROUGHNESS:

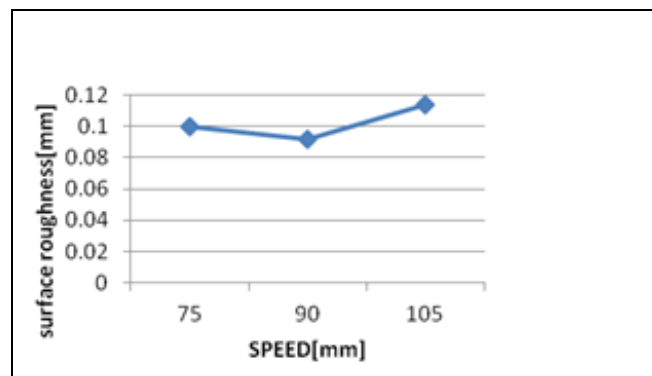


Fig 6: SPEED vs SURFACE ROUGHNESS:

The figure 7 shows the film adhesiveness with respect to the distance of the spray paint gun from the object to be painted. From the figure7 it is understood that the film adhesiveness is decreased as the distance increases.

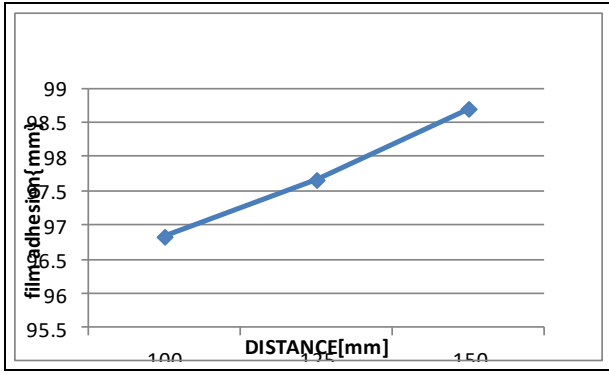


Fig 7: DISTANCE VS FILM ADHESION

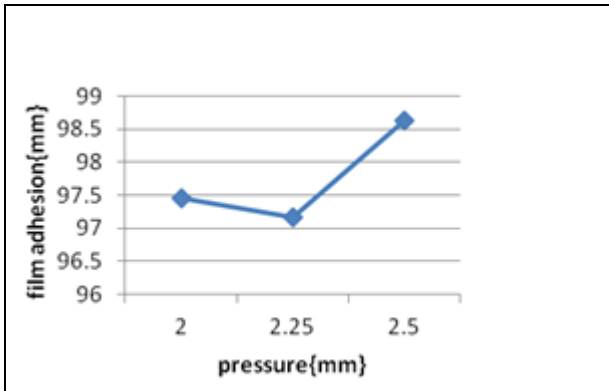


Fig 8 : PRESSURE VS FILM ADHESION

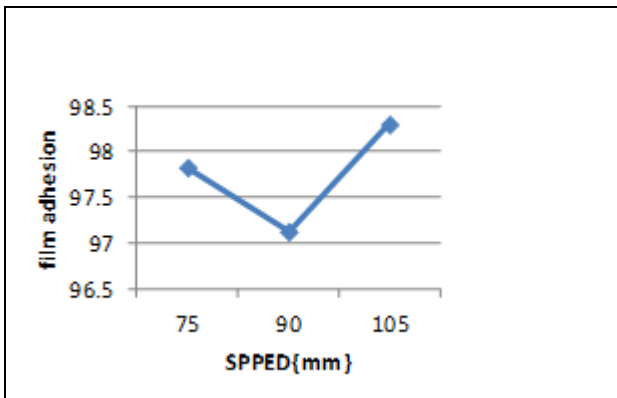


Fig 9: SPEED VS FILM ADHESION

The regression model for the Thickness variation for the three input a variables in using Taguchi method has been found as

$$C4 = -24.2 + 0.2000 C1 + 8.33 C2 - 0.094 C3 \quad (1)$$

In this C4 represents the Thickness variation C1 represents the distance, C2 represents pressure, C3 represents speed. The residual plot for the same is shown in fig 10

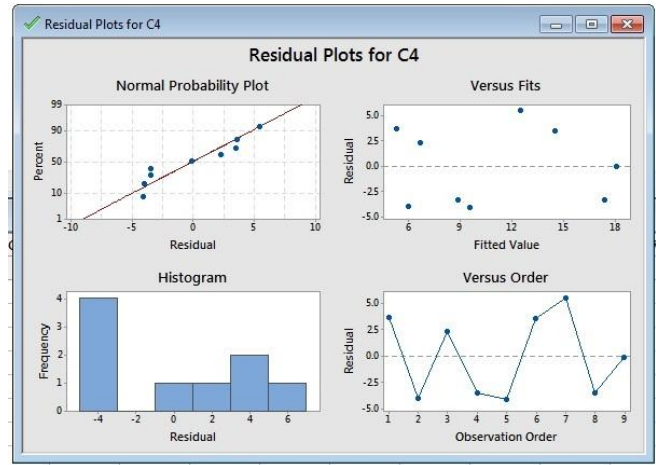


Fig 10. Residual plots for Thickness variation.

The regression model for the surface roughness with respect to the variables distance , pressure and speed is given by

$$C5 = -0.0686 - 0.000560 C1 + 0.0933 C2 + 0.000433 C3$$

Where C5 represents surface roughness and fig 11 shows the residual plots for the regression analysis of surface roughness

The regression model for the Film Adhesion with respect to the variables distance , pressure and speed is given by

$$C6 = 87.08 + 0.0387 C1 + 2.00 C2 + 0.0156 C3 \quad (3)$$

Where C6 represents Film adhesion and fig 12 shows the residual plots for the regression analysis of surface roughness

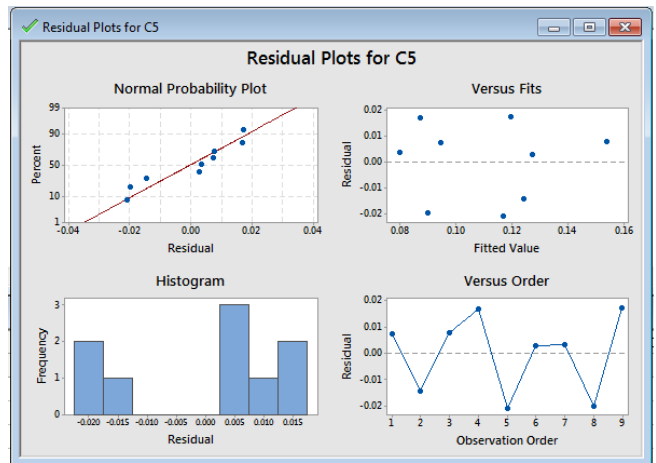


Fig 11: Residual plots surface roughness

The regression models are obtained for three observations separately. The best fit occurs for the three observations occurs at distance (150 mm), pressure (2.5 bar), speed (90 mm/sec).

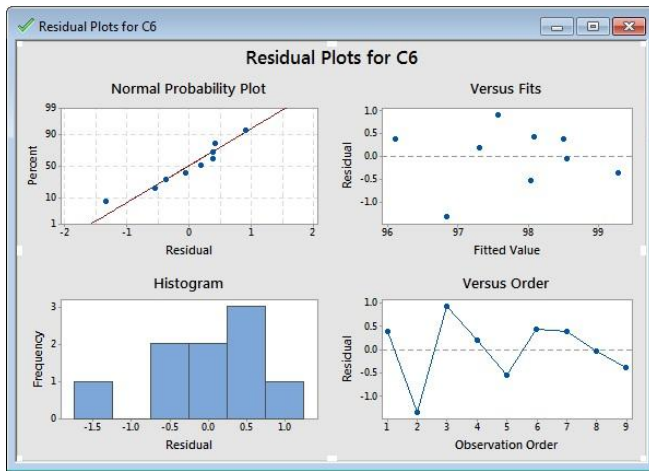


Fig 12: Residual plots for Film adhesion

III. CONCLUSION:

This paper analyzed the characteristics of an automated spray painting using taguchi with the HVLP GUN which reduces the cost. The most influencing factors distance (150 mm), pressure (2.5 bar), speed (90 mm/sec) were explored and achieved by regression model.

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